The Salton Seismic Imaging Project: Investigating Earthquake Hazards in the Salton Trough, Southern California

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Abstract

The Salton Seismic Imaging Project (SSIP) is a collaborative effort between academia and the U.S. Geological Survey to provide detailed, subsurface 3-D images of the Salton Trough of southern California and northern Mexico. From both active- and passive-source seismic data that were acquired both onshore and offshore (Salton Sea), the resulting images will provide insights into earthquake hazards, rift processes, and rift-transform interaction at the southern end of the San Andreas Fault system. The southernmost San Andreas Fault (SAF) is considered to be at high-risk of producing a large damaging earthquake, yet the structure of this and other regional faults and that of adjacent sedimentary basins is not currently well understood.

Seismic data were acquired from 2 to 18 March 2011. One hundred and twenty-six borehole explosions (10-1400 kg yield) were detonated along seven profiles in the Salton Trough region, extending from area of Palm Springs, California, to the southwestern tip of Arizona. Airguns (1500 and 3500 cc) were fired along two profiles in the Salton Sea and at points in a 2-D array in the southern Salton Sea. Approximately 2800 seismometers were deployed at over 4200 locations throughout the Salton Trough region, and 48 ocean-bottom seismometers were deployed at 78 locations beneath the Salton Sea. Many of the onshore explosions were energetic enough to be recorded and located by the Southern California Seismograph Network.

The geometry of the SAF has important implications for energy radiation in the next major rupture. Prior potential field, seismicity, and InSAR data indicate that the SAF may dip moderately to the northeast from the Salton Sea to Cajon Pass in the Transverse Ranges. Much of SSIP was designed to test models of this geometry.

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Figure 1. Map showing extent of the Salton Seismic Imaging Project (SSIP). Major roads shown in pink. Seismic Lines 1 through 7 are labeled. Line 1 labeled in three segments - 1N, 1M, and 1S.

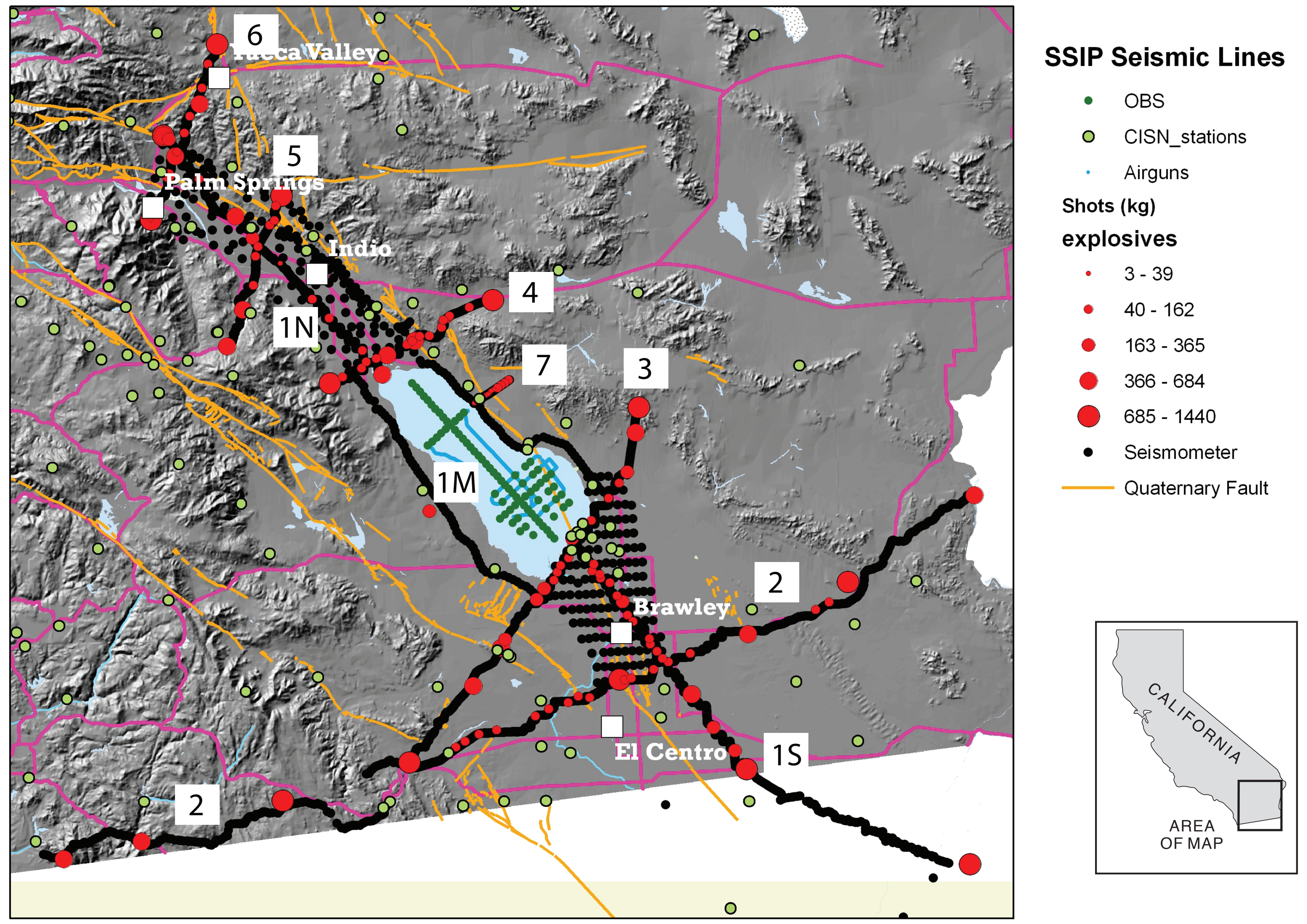
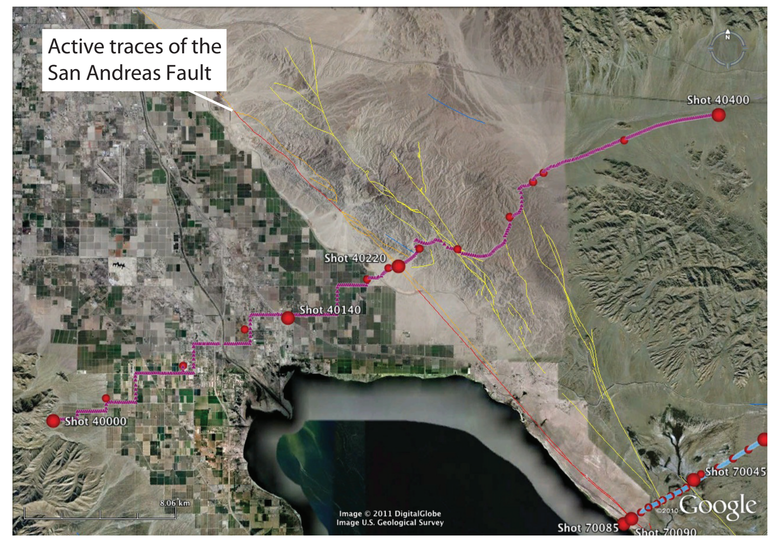


Figure 2. Seismic Profile 4

This SW-NE trending, 40 km-long profile spans the width of the lower Coachella Valley from the Santa Rosa Mountains in the SW; through Box Canyon in the Mecca Hills to the NE; to just a few km south of Interstate 10 near Chiriaco Summit. This profile will illuminate the thickness of unconsolidated valley fill sediments whose amplified shaking during earthquakes poses a significant hazard to communities in the valley. The geometry of the San Andreas Fault (orange and red lines in the photo at right) will affect how severe the shaking will be. The location photo on the right shows the zig-zag deployment of receivers as purple triangles and the shotpoints as red dots. Larger dots indicate shots for which record sections are shown below.



Line 4- Box Canyon- Shot Gathers

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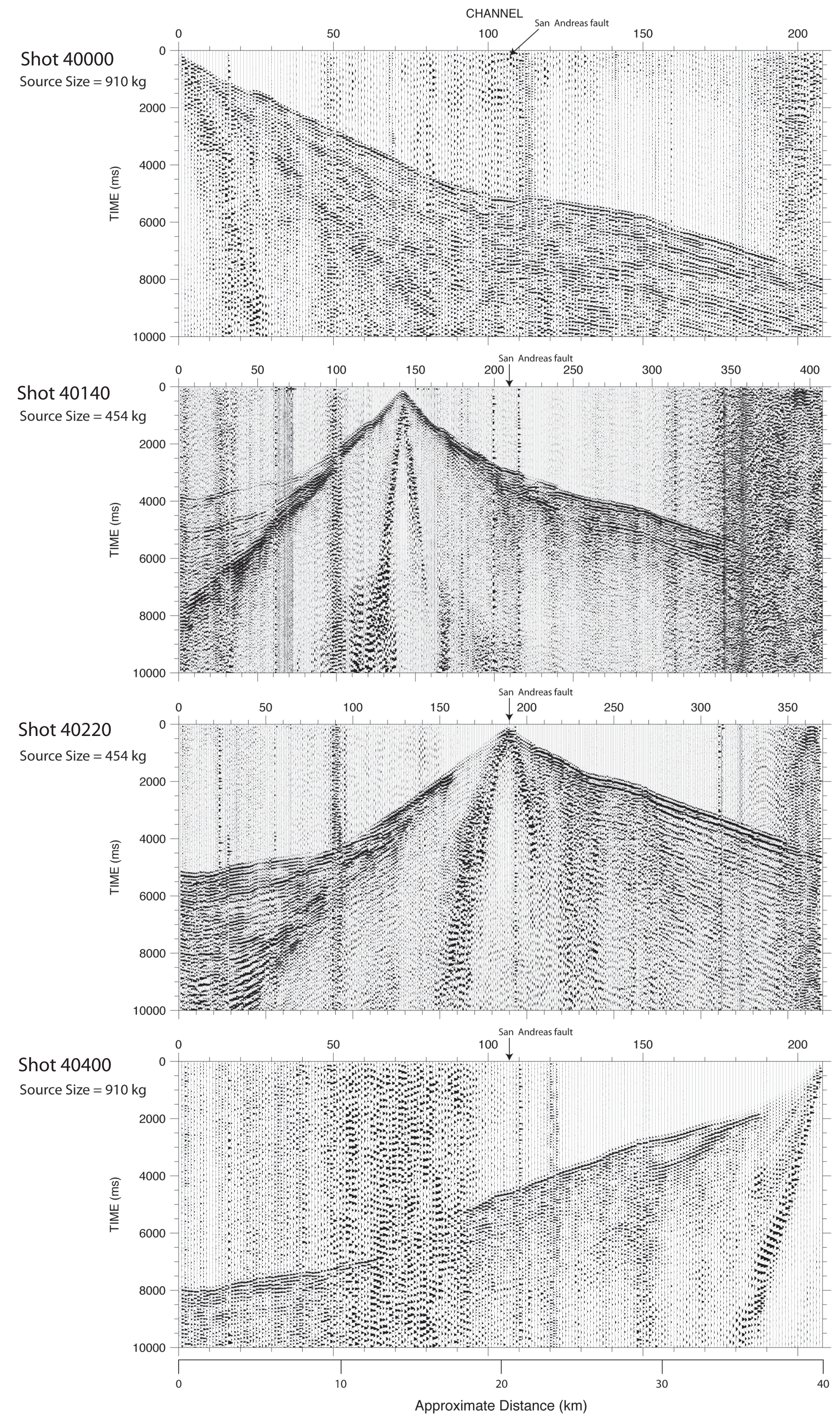
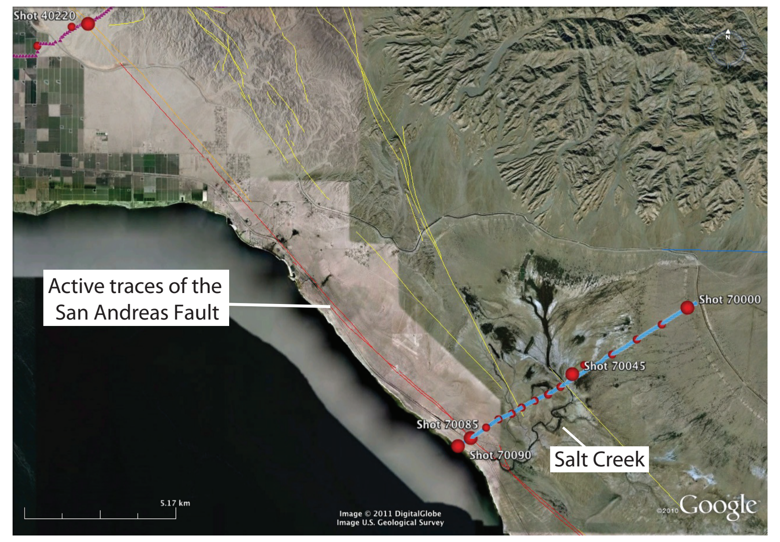


Figure 3. Seismic Profile 7

This SW-NE trending, 9 km-long profile spans the width of the San Andreas Fault zone near the paleoseismic study site at Salt Creek, on the eastern shore of the Salton Sea. This profile will illuminate the the geometry of the San Andreas Fault (orange and red lines in the photo at right) in the region where the next large earthquake in the region is likely to nucleate. The location photo on the right shows the shotpoints as red dots. Larger dots indicate shotpoints for which record sections are shown below. Receivers are defined by blue triangles. OBS's and airgun shots extended this profile offshore (see Fig. 1).



Compare this profile to that of Line 4 (40 km) and note that the results below were obtained with small amounts of explosives.

Line 7- Salt Creek- Shot Gathers

agc = 10000, bandpass 2-4-8-16

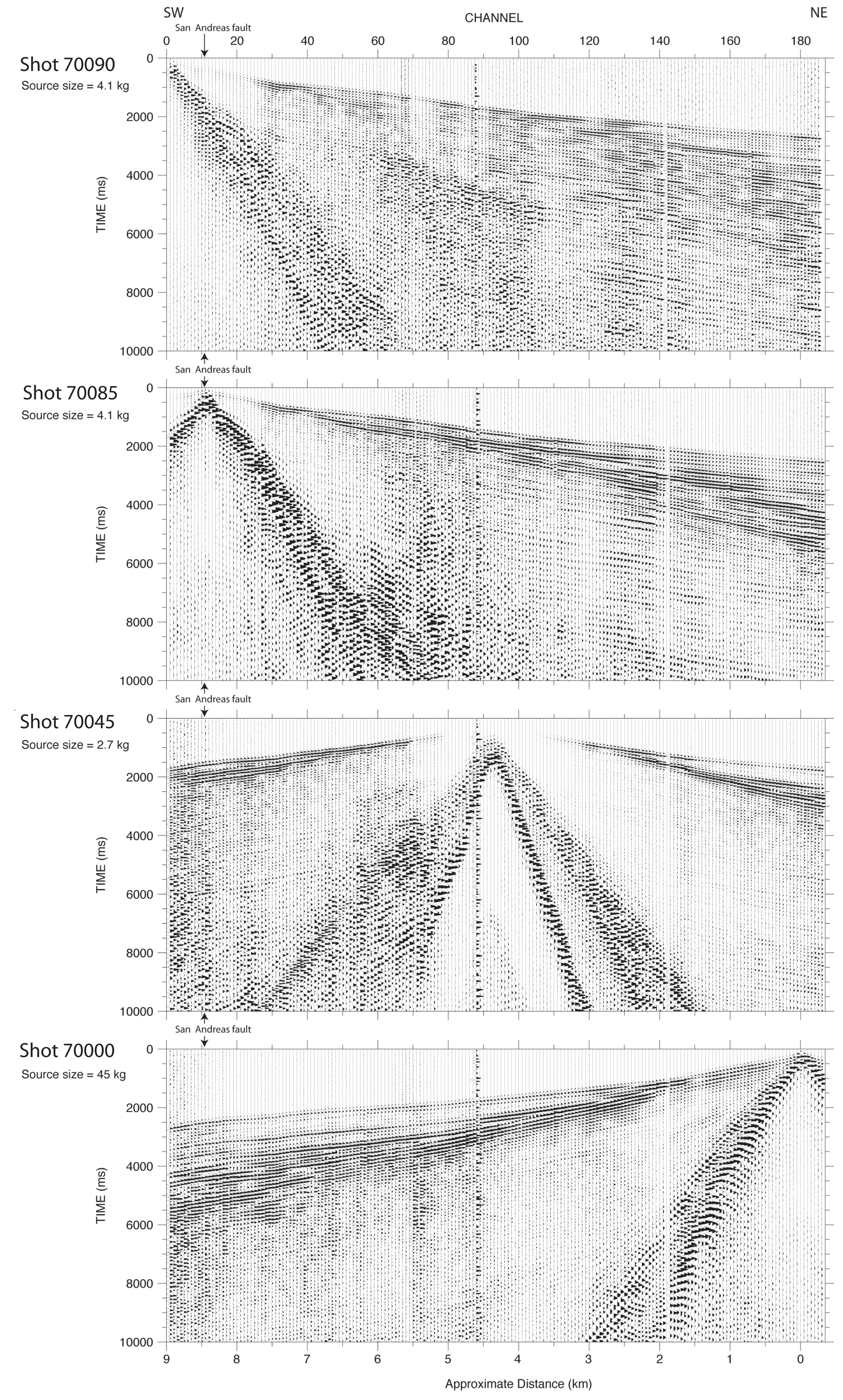


Figure 4. Models for Line 4

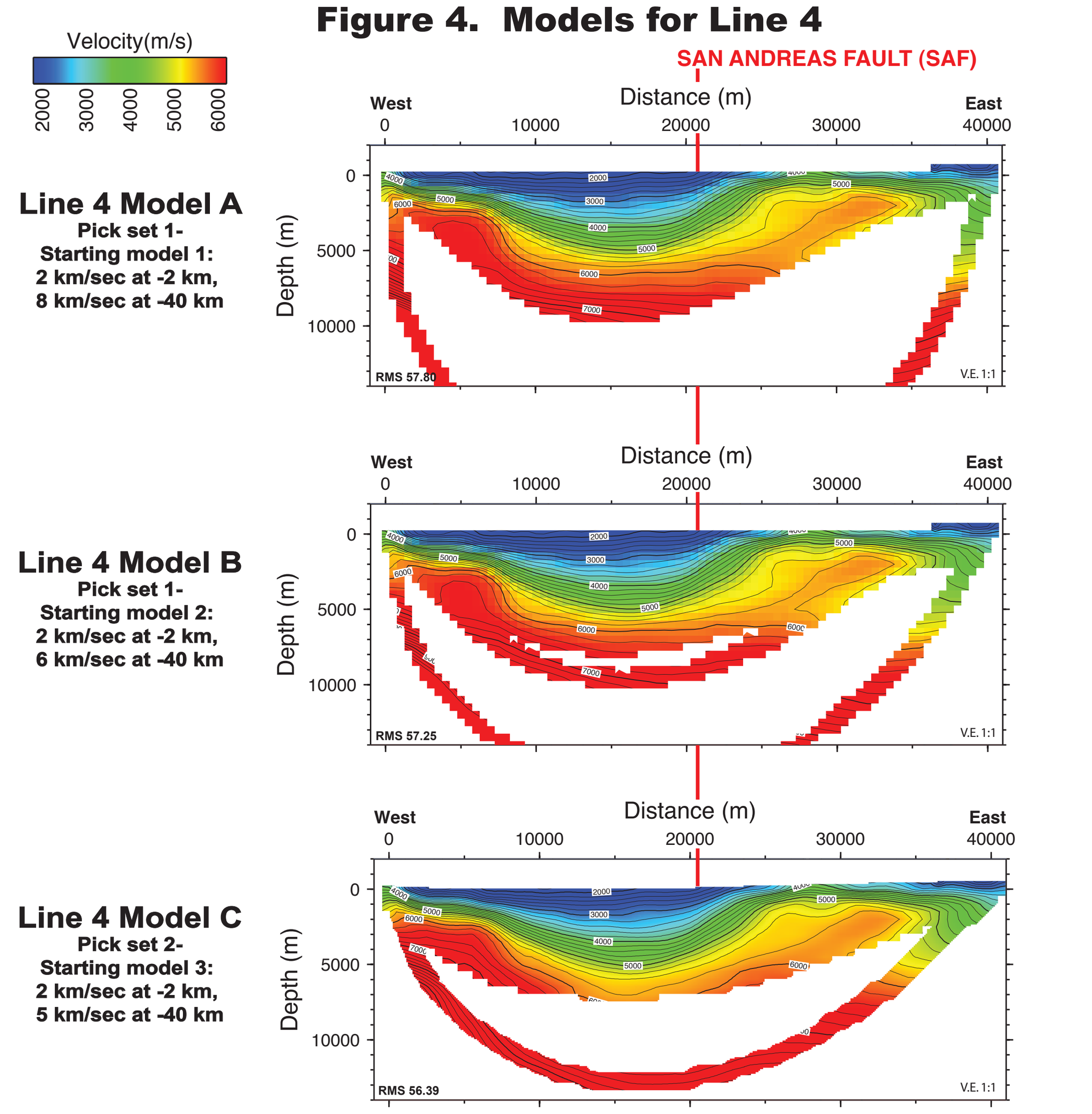


Figure 5. Model for Line 7

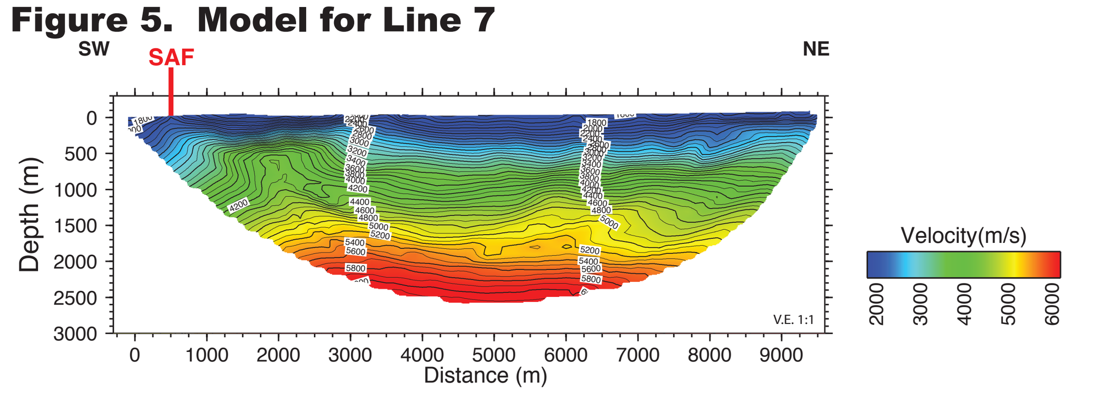
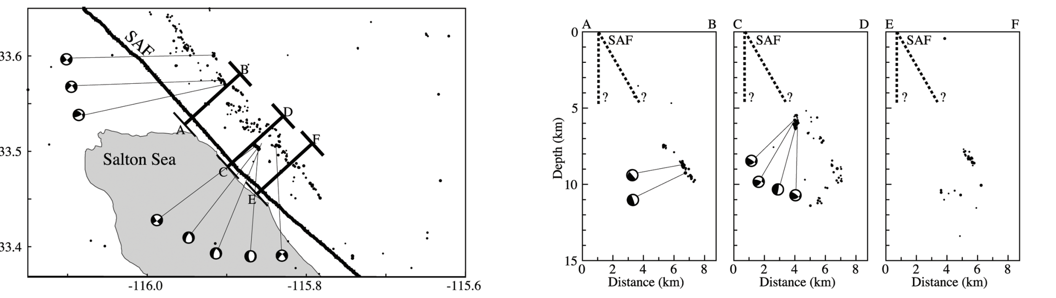


Figure below shows regional seismicity in map view and labeled cross sections (Lin, Shearer, and Hauksson, 2007). Seismicity below 5-km depth appears to define a plane that projects to the surface at the trace of the SAF. Dip of the plane is 57-59 degrees. Our goal on Line 7 is to determine whether a northeast dip of the SAF is also supported in the upper few kilometers of crust. It appears to be (see Summary).



Summary

Approximately 3 million seismograms were collected during SSIP. These data provide insight into basin geometry and velocity structure, as well as dip of the San Andreas Fault. Preliminary models for two of the seven seismic profiles are presented here. The preliminary model for Line 4 shows the basin to be 5 km deep and asymmetric. The preliminary model for Line 7 was constructed from land data only. In the future however, airgun and OBS data from the Salton Sea will be included in the model, which will give a better image of the San Andreas Fault at Salt Creek.

In both models for Lines 4 and 7, interpretations of a moderate eastward dip are possible, and are consistent with relocated hypocenters along the SAF. The interpretation of a moderate eastward dip is more convincing for Line 7.